Thayer, G.W. and P.F. Sheridan. 1999. Fish and aquatic invertebrate use of the mangrove prop-root habitat in Florida: a review, p. 167-174. *In:* A. Yáñez-Arancibia y A.L. Lara-Domínguez (eds.) Ecosistemas de Manglar en América Tropical. Instituto de Ecología, A.C. México, UICN/ORMA, Costa Rica, NOAA/NMFS Silver Spring MD USA. 380 p.

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Fish and Aquatic Invertebrate Use of the Mangrove Prop-root Habitat in Florida: A Review

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Abstract

While the red mangrove prop-root habitat has been recognized as a fishery habitat for a considerable period of time, few quantitative studies have been conducted to assess their use by fauna. Techniques have been developed and tested recently in Florida that allow hypothesis testing and evaluation of the functional value of this habitat to fishery organisms. Preferred techniques include block nets and drop samplers, and in most instances even these techniques require some minor modification of the habitat before sampling can be initiated. The limited quantitative sampling that has occurred indicates that commercial, recreational and forage fish and crustaceans are important users of the prop-root habitat, and that there are temporal and spatial differences in community structure among these habitats in Florida. This chapter provides a brief summary of the data available for Florida.

Resumen

Mientras que los habitas de las raíces de sostén del manglar rojo han sido reconocidos como un hábitat de pesca por un periodo de tiempo considerable, pocos estudios han sido realizados para evaluar su uso por la fauna. Las técnicas que han sido desarrolladas y probadas recientemente en Florida que permite probar la hipótesis y evaluar de su valor funcional de este hábitat para organismos con importancia pesquera. Las técnicas preferidas incluyen redes de bloque (block nets) y muestreadores de caída (drop samplers), y en la mayoría de los casos aún estas técnicas requieren alguna pequeña modificación del hábitat antes del muestreo pueda ser iniciado. El muestreo cuantitativamente limitado que han ocurrido indican que los peces y crustáceos de importancia co-mercial, recreativa y de forraje son usuarios importantes de los hábitat de sostén, y que existen diferencias temporales y espaciales en la estructura de la comunidad entre estos hábitats en Florida. Este capítulo proporciona un breve resumen de los datos disponibles para Florida.

Introduction

Mangroves represent a major coastal wetland habitat in the southeastern United States, occupying about 202,000 ha of estuarine and coastal shoreline (Odum *et al.*, 1982). As noted by Thayer et *al.* (this volume), the functional roles these systems play in supporting primary and secondary production of coastal waters are poorly understood. It is critical to understand these roles because mangroves continue to be replaced by housing developments, mariculture facilities, canals and other forms of human development. We believe that a significant portion of this habitat loss results from the lack of quantitative data available to resource managers on the value of mangrove systems: spatial and temporal use by fishes and invertebrates, and their food and refuge potentials for aquatic species.

While it has long been recognized that red mangrove habitats in the southeastern United States are important to fishery resources (see Odum *et al.*, 1982), there have been few quantitative studies dealing with the use of these habitat types and their functional value to fishery organisms (see Thayer *et al.*, 1987; 1988; Sheridan, 1991). This general paucity of quantitative information stems largely from the lack of techniques to address the contribution of mangroves to fishery organisms. Recently, however, several techniques have been developed and tested, with results published in the open scientific literature or in abstracts for scientific meetings, agency annual reports or funding reports. It is the purpose of our paper to review several of the published manuscripts and available information from other sources, and by necessity this requires direct use of some of the information and data from these sources. The authors (GWT and PFS) have published the papers upon which much of this chapter is based, and we have attempted to include information yet to be published or not easily obtained for the Florida mangrove habitat that we were aware existed. In-so-doing, we inadvertently may have omitted some papers and reports, for which we apologize to those scientists.

Techniques

The red mangrove canopy and prop-root structure have presented formidable obstacles to evaluating the temporal and spatial distribution and abundance of fishes and decapod crustaceans utilizing this habitat type. This is a major area that has been recommended for investigation by a recent scientific workshop held in St. Petersburg, Florida (Thayer *et al.* this volume). Visual censes have been used frequently, and are advantageous in determining use of prop-root habitats by large predators; can be used to quickly survey areas; require little equipment and no habitat distruction; and can be used in deep areas where nets and rotenone may be difficult to use (J. Ley, Univ. Florida, pers. comm.). This approach does not work well under turbid conditions characteristic of many mangrove habitats. Techniques that have evolved recently to sample fish and macroinvertebrates of the red mangrove prop-root habitat fall into three major categories: block sampling, drop sampling and traps.

In western Florida Bay, where tidal amplitude is small, Thayer *et al.* (1987, 1988) used a block net procedure. The block net was 32 x 2 m in size with 3 mm mesh. The bottom of the net was fitted with 6 mm galvanized chain and the top with a cork line. Wooden staffs were fixed to each end of the net. Prior to any sampling, 2.8 m long pipes were driven into the sediment 4-8 m apart at the seaward corners of each mangrove site to be sampled. Then, a 0.5 m wide path was cleared to the shoreline from each stake perpendicular to the shoreline to allow the net to be moved up along the sides of the site.

The blocking procedure involved 2 individuals who approached to within about 5 m of the site by boat, and then deployed the net at about peak high tide. The net was carried rolled up to the center of the stakes which had been set at the seaward edge of the site. The net was unfurled and spread out by passing it around the outside of the stakes. Each individual then moved the net up a cut path between mangroves onto the shore, pulling the net tight as they moved. The chain line was checked immediately and pushed into the sediment to prevent escape of organisms. Therefore, the net blocked the front and sides of each sample area with the shoreline forming the interior border.

Sampling was conducted after application of 5% rotenone (w/w), diluted about 1:4, that was dispensed below the surface of the water. Four individuals then positioned themselves adjacent to the net or within the blocked area and used dip nets to capture surfacing organisms over the next 30 minutes. The chain line was then lifted and fish settling on the net were removed. Fin-clipped fish of a variety of species were added as a check for collection efficiency, which averaged about 75% during every month but January.

Ley (1991; 1992, pers. comm.) and Ley and Montague (1991) also have used this block net and rotenone technique to sample fish in northeastern of Florida Bay near the Buttonwood Sound-Long Sound-Joe Bay complex. Ley (1990) carried out capture efficiency analyses using fin-clipped fishes of a variety of species with recoveries of 12-72 % and a mean recovery of 36 %; larger species were collected more efficiently than smaller species. These efficiencies are considerably lower than those recorded by Thayer *et al*. (1987). Mullin (1995) used block nets to surround small (12-25 m^2) overwash islands in Tampa Bay at high tide and then collected fishes at low tide when the islands were dry.

Florida Department of Natural Resources is employing a passive block net technique to sample fish use of mangrove habitats in Tampa Bay and currently is contemplating conducting similar work in Charlotte Harbor (McLaughlin pers. comm.). This technique requires a tidal prism to drive organisms out of the habitat in question, and modifications of this technique have been receiving increasing use in studies of other tidal wetland systems (e.g. Hettler, 1989). They have been employing a 63 m long net that is 2.5 deep and has a 2.5 x 2.5 x 2.5 m tail bag. The net is brought up onto the shore to the high tide mark on each side of the sample area at high tide and allowed to fish during the ebb tide, after which the catch is removed from the tail bag (McLaughlin pers. comm.). Sampling began in November 1990 and data are not available at this time; however, capture efficiencies using marked fish of several species and size classes appear to be 60-70%.

Very recently, portable and stationary drop samplers have been employed in mangrove systems to assess the use of the prop-root habitat by fish and invertebrates. Sheridan (1992) sampled using a 1.8 m (diameter) circular drop sampler developed by Zimmerman *et al*. (1984). Fixed mangrove sites were used in this study with a maximum depth of 1 m. In each instance a 0.5 m path was cleared around each site by cutting prop-roots to the sediment surface, and in some instances overhanging limbs were removed.

Sampling was carried out by hoisting the sampler on a boom mounted on the bow of a sampling boat (see Zimmerman *et al*., 1984) and maneuvering the boat quietly to the sampling site. The sampler was dropped to the substrate and subsequently pushed into the sediment 15-20 cm to seal off the sample. Water enclosed by the sampler then was pumped out through a 1 mm mesh plankton net, and the organisms remaining on the substrate were picked up. Previous testing by the author (PFS) indicated an overall recapture rate of 82-94% for fish, shrimp and crabs in a variety of habitats.

Lorenz (1991, pers. comm.) and Lorenz *et al*. (submited), working in brackish water areas in the northern side of Florida Bay, is using a stationary drop net sampling approach, similar to that commonly used in seagrass habitats (Fonseca *et al*., 1990). The 9 m^2 nets are hung on permanently mounted frames of #3 reinforcement bar crossbeams and 1 inch PVC uprights at each corner. The crossbeams rest on 15 cm long cotter pins inserted through each PVC corner pole so that the crossbeams are supported approximately 1 m above the water surface. The end of each crossbeam encircles the corner poles and each has five 20 cm-long V-shaped wire staples attached at equal distances along its length with the open end of the V-staple turned upwards.

The nets are 1.5 m wide with 1.6 mm mesh. A float line of each net is attached to the top of each PVC pole and the lower end of the net is slipped under the inside of each crossbeam and fitted over the outside upright of each of the V-staples.

The nets are allowed to stand overnight, and are triggered the following day from a distance of about 10 m by lines attached to each of the four cotter pins. The weight of the crossbeams makes the net sink to the bottom and forces the bottom of the net into the sediment. Rotenone and dip nets are used to collect the dead fish from within the net over a 24 h period. Efficiency tests indicate recoveries of between 63-92%.

Traps have been used in several studies to survey the fishery organisms utilizing mangrove prop-root habitats (Gilmore *et al*., 1987; Ley, 1990, 1991), but there is no way to quantify the area fished by a trap. Gilmore and coauthors used heart traps (a small minnow trap with one entrance and shaped like a heart) that were set for 24 hr at two locations on the east-central coast of Florida under the red mangrove canopy. On several occasions, throw traps adjecent to mangrove root habitats have been used to provide quantitative measures of fish abundance (Gilmore *et al*., 1987).

Each of the methods noted above has its advantages and disadvantages. The block net approach requires some modification of the habitat and can be used in both low and high tidal amplitude areas; in low tidal amplitude areas, fish poisons must be used. The drop sampling approaches also require some modification of the habitat and are limited to shallow depths for sampling. Never-the-less, these are quantitative approaches to addressing the problem of temporal and spatial use of the prop-root habitat that have provided critical information for habitat managers on the value of these habitats to fisheries. These approaches also have begun to address functional issues that are described by Thayer *et al.* (this volume).

Summary of Faunal Use Data

In reviewing some of the literature on fish use of mangrove swamps, particularly those on the Atlantic coast of Florida, Gilmore and Snedaker (In press) indicated that there are both resident and transient species, and that the numerically abundant mangrove swamp resident fish species also are common in peripheral high marsh habitats of Florida. They noted that mosquitofish (*Gambusia affinis*), sailfin molly (*Poecilia latipinna*) and sheepshead minnow (*Cyprinodon variegatus*) are numerical dominants. They pointed out further that tide water silverside (*Menidia beryllina*), fat sleeper (*Dormitator maculatus*), and rivulus (*Rivulus marmoratus*) also are common residents. Transient species are more diverse in this system than are the residents, and appear to be dominated by striped mullet (*Mugil cephalus*), white mullet (*M. curema*), snook (*Centropomus undecimalis*), ladyfish (*Elops saurus*), Irish pompano (*Diapterus auratus*), yellowfin mojarra (*Gerres cinereus*), tidewater mojarra (*Eucinostomus harengulus*), sheepshead (*Archosargus probatocephalus*), and gray snapper (*Lutjanus griseus*). These observations are based primarily on heart and throw trap collections. Most of these transients are commercially or recreationally important species.

Quantitative studies by Thayer *et al.* (1987, 1988) and Sheridan (1992) with block nets and drop samplers have demonstrated that there appear to be different complexes of fish in mangrove habitats of Florida and Rookery Bay (Gulf of Mexico coast), and the mangrove habitats on the Atlantic coast evaluated by Gilmore *et al.*, 1987). These studies indicate that there appears to be a fish community in the mangroves that is distinct from that of the adjacent seagrass habitat; some of the species are similar between the two habitats but they comprise a different fraction of each community.

Thayer *et al.* (1987) collected 64 species and 32 families of fish from among the mangrove prop-roots during seven surveys in 1984-1985 in western Florida Bay, Coot Bay and Whitewater Bay, Everglades National Park, Florida. The mean density of fish was 8/m^2. Fishes of the families Atherinidae, Cyprinodontidae, Gerreidae, Engraulidae and Gobiidae were represented most abundantly among the red mangrove prop-roots. The predominant fishes collected were forage species: hardhead silverside (*Atherinomorus stipes*), silver jenny (*E. gula*), goldspotted killifish (*Floridichthys carpio*), spotfin mojarra (*E. argenteus*), code goby (*Gobiosoma robustum*), rough silverside (*Membras martinica*), striped anchovy (*Anchoa hepsetus*), and clown goby (*Microgobius gulosus*). These forage species are common dietary items for several species of piscivorous birds and fish.

Thayer *et al.* (1987, 1988) also collected juveniles of several commercial and recreational species in the mangrove prop-root community: snook, gray snapper, spotted seatrout (*Cynoscion nebulosus*), red drum (*Sciaenops ocellatus*), striped and white mullets (*M. cephalus, M. curema*), sheepshead, and great barracuda (*Sphyraena barracuda*). Although these fishes were present in the block net collections on a routine basis, they never were as abundant as forage fish species.

Ley (1991, 1992) and Ley and Montague (1991), also used a block net system, worked in areas of eastern Florida Bay having harsh environmental conditions, with salinity ranging from 0-50 ppt and temperatures ranging from 4-37 degrees C. The fish community appeared to be dominated by small species and juveniles of larger species, and during 6 months of sampling 48 species of fish had an average density of 3.3 fish/m^2. The dominant organisms were euryhaline species that frequently serve as forage food for fishes and birds: silversides, anchovies and killifish. Ley (1992) supplemented these block net samplings with minnow trap collections and visual observations, and has noted recreational species such as blue-striped grunt (*Haemulon sciurus*) and gray snapper among the prop-roots. The composition of the community did not appear to differ greatly from that observed by Thayer *et al.* (1987, 1988) in the western Florida Bay complex.

Ley (1992) also has been investigating temporal and spatial distribution of fishes. She has observed that average fish density appeared to be lower in upstream areas of the study sites that were subject to more variable salinities, and higher in down stream areas where salinities tended to be more stable. Subsequent sampling showed similar trends, but statistical analyses are showing it to be a trend and not significant (Ley, pers. comm.). Species composition also appeared to follow a similar trend with more variability in the upstream areas and less in the mangrove prop-root areas located downstream near or in Florida Bay. At the time of this writing, Ley has just completed her Ph.D. degree at the University of Florida (Ley, 1992), and the authors thank her for use of her data.

Lorenz (1991 and in Powell and Bjork, 1990) is sampling red mangrove habitats in interior portions of the northern Florida Bay area which have salinities between 10 and 50 ppt. Similar to observations by Ley (1991) and Thayer *et al.* (1988), he is finding that sheepshead minnow, marsh killifish and sailfin molly are the predominant species collected by the drop net approach. Total fish densities have ranged between less than 1 and in excess of 8 fish/m^2, with the majority of fish collected being less than 5 cm in total length. This investigator has noted that these small fish are pre-dominant food sources for the roseate spoonbill (*Ajaia ajaja*). Lorenz currently is conducting research for an advanced degree at the University of Florida and is a Cooperative Research assistant for the National Audubon Society Research Unit and the Department of Wildlife and Range Sciences at the University. The authors thank him for the use of his preliminary data on techniques and fisheries in mangrove habitats.

Northwest of Florida Bay, Sheridan (1992) conducted quantitative sampling of the mangrove prop-root habitat in Rookery Bay, using a drop sampler, and demonstrated a somewhat different and less diverse fish community than was noted for Florida Bay. The community of fish in this area contained only 13 species, dominated by the spotfin mojarra which represented 75% of the fish collected. Fish densities averaged 5.8/m^2. Goldspotted killifish, marsh killifish (*Fundulus confluentus*), and sailfin molly also were contributors to the population and were primarily present in this habitat relative to other habitats sampled (i.e., open water and seagrass meadows nearby). Organisms such as spotfin mojarra, pinfish (*Lagodon rhomboides*), and gray snapper were able to exploit flooded mangroves along with other habitats in Rookery Bay, but species such as scaled sardine and anchovies that were present in mangrove habitats in Florida Bay rarely moved into the Rookery Bay mangrove habitat.

Both Sheridan (1992) and Thayer *et al.* (1987; 1988) recognized that there could be diel differences in species composition of these mangrove habitats (sampling was carried out primarily during daylight hours). Thayer *et al.* (1988) conducted a few comparative day-night samplings in Florida Bay. The small database suggested juvenile great barracuda, goldspotted killifish, spotfin mojarra, tidewater silverside (*M. peninsulae*), and timucu (*Strongylura timucu*), were taken more frequently from the mangrove habitat during the day while redfin needlefish (*S. notata*) and gray snapper were encountered more frequently at night. Whether these movements are directed as feeding migrations or refuge are unknown, but night sampling might provide additional information as to fishery use of this habitat type as well as linkages among habitats.

Sheridan (1992) also investigated the invertebrate use of mangrove habitats. This study appears to be the only one in Florida to address aquatic invertebrate use of mangrove prop-root habitats quantitatively. Florida grass shrimp (*Palaemon floridanus*) was the dominant shrimp collected among the prop-roots followed by daggerblade grass shrimp (*Palaemonetes pugio*). Five shrimp species averaged 3.9 individuals/m^2. Among 9 species of crabs, the broadback mud crab (*Eurytium limosum*), green porcelain crab (*Petrolisthes armatus*), and mangrove tree crab (*Aratus pisonii*) were the most prevalent. Crab densities averaged 3.6/m^2 in the Rookery Bay mangrove system. Both Sheridan (1992) and Thayer *et al.* (1987, 1988) noted that the mangrove prop root did not appear to be an important habitat for commercial blue crab (*Callinectes sapidus*), stone crab (*Menippe mercenaria*), rock shrimp (*Sicyonia* spp) or pink shrimp (*Penaeus duorarum*) in the areas they sampled.

Conclusions

The development and testing of quantitative sampling approaches for use in the mangrove prop-root habitat have allowed testing of scientific hypotheses and gathering of data that are important to habitat managers in their quest to conserve and protect valuable natural resources. Until recently, these techniques have not been available and the information base on importance of this habitat has been limited to visual census in clear water environments. The preferred gear at this time are block nets and drop samplers, and recently these techniques have been used successfully in a variety of mangrove prop-root habitats in Florida to assess fish and invertebrate use.

Quantitative sampling has shown that this habitat is utilized by transient and resident fishes and invertebrates representing forage, commercial and recreational species. Data suggest that the majority of the species are adults of small individuals or juveniles of many species including piscivorous fish. Densities appear to range between 3-8 fish and 7-8 decapods/m^2 for those studies reporting densities. There also are temporal and spatial differences in species composition and diversity that appear to be a function of geographic location (e.g., Florida Bay *vs* Rookery Bay) or as extremes of conditions along a salinity gradient (e.g., within the Florida Bay complex). There are limited indications that diel differences exist in the composition of the community. Where data are available (e.g., Rookery Bay), they suggest that invertebrates are more diverse than the fish community and are dominated by caridean shrimp and xanthid crabs.

These few studies have just scratched the surface, but they have demonstrated that the prop-root habitat is an important one for fish and invertebrates of food web, commercial, and recreational value. There also are indications of linkages among this habitat type and adjacent seagrass, open water and marsh habitats. Efforts need to be increased to evaluate this and more extensively flooded mangrove habitats for their relative value to fish and crustaceans. The techniques developed provide the avenue to address spatial and temporal variation in habitat use in relation to water level and to compare feeding and refuge potentials among mangrove habitats and among other vegetated and unvegetated coastal and estuarine habitat types.

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